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OPTICAL DISK SUBSTRATE AND  
LIGHT GUIDE PLATE

**DECLARATION**

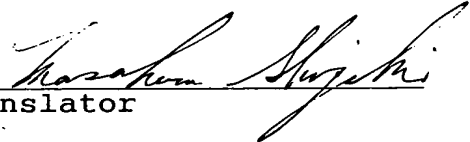
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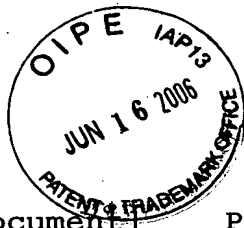
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I, Masaharu Shizuki, declare and say:  
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English languages;  
that I am presently engaged as translator in these  
languages;  
that the attached document represents a true English  
translation of the Japanese Priority Application  
No.2002-110084, filed April 12, 2002.

I further declare that all statements made herein of my  
own knowledge are true and that all statements made on  
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that these statements were made with the knowledge that willful  
false statements and the like so made are punishable by fine  
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may jeopardize the validity of the application or any patent  
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Signed this 12th day of May, 2006.

  
Translator



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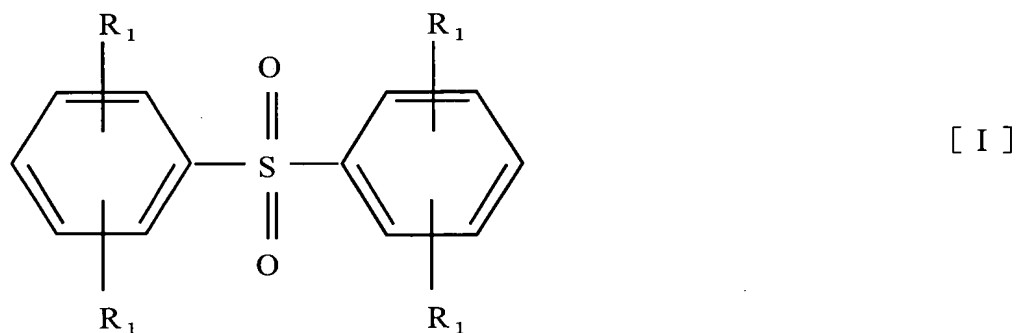
[Title of Invention]

Polycarbonate resin composition and optical disk substrate formed therefrom

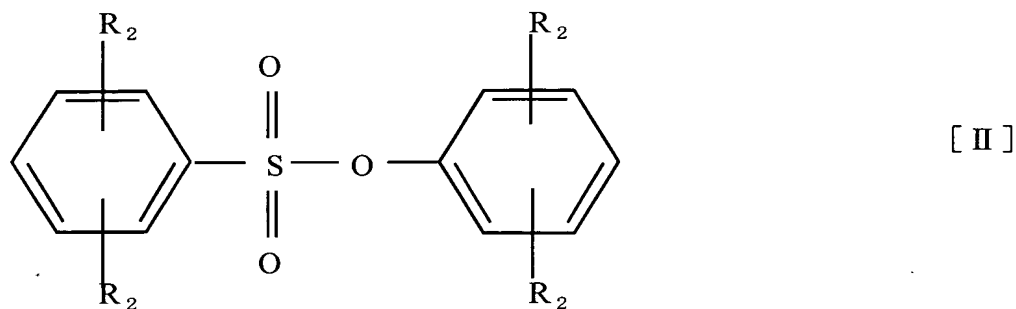
[Claims]

[Claim 1] A polycarbonate resin composition comprising 0.1 to 20 parts by weight of a diphenyl sulfone compound represented by the following formula [I] and/or a phenylsulfonic acid phenyl ester compound represented by the following formula (II) based on 100 parts by weight of the polycarbonate resin.

[Formula 1]



[Formula 2]



(wherein a plurality of R<sub>1</sub>s and/or R<sub>2</sub>s independently represents a hydrogen atom, a halogen atom, an alkyl group having 1 to 8 carbon atoms, an aryl group having 6 to 10 carbon atoms, an alkoxy group having 1 to 8 carbon atoms, a cyano group, a nitrile group, a carboxyamide group or a carboxyimide group.).

[Claim 2] The polycarbonate resin composition of claim 1,

wherein the plurality of  $R_1$ s independently represents a hydrogen atom, a halogen atom, an alkyl group having 1 to 8 carbon atoms, an aryl group having 6 to 10 carbon atoms or an alkoxy group having 1 to 8 carbon atoms.

[Claim 3] The polycarbonate resin composition of claim 1 or 2, wherein the polycarbonate resin is a polycarbonate resin having a viscosity average molecular weight of 10,000 to 30,000, measured in a 20°C methylene chloride solution.

[Claim 4] An optical molding material formed from the polycarbonate resin composition of any one of claims 1 to 3.

[Claim 5] An optical disk substrate molded by using the optical molding material of claim 4.

[Claim 6] An optical disk substrate molded by using the optical molding material of claim 4, which has a distance between grooves or pits is 0.1  $\mu\text{m}$  to 0.8  $\mu\text{m}$ .

[Claim 7] The optical disk substrate of claim 6, wherein the optical depth of a groove or pit molded by using the optical molding material of claim 4 is in a range of  $\lambda/8n$  to  $\lambda/2n$ , when the wavelength of laser beam used for recording and reproduction is  $\lambda$  and the refractive index of the substrate is  $n$ .

[Claim 8] An optical recording medium using any one of the optical disk substrate of claims 5 to 7.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to a polycarbonate resin composition having high rigidity, precise transferability to the shape of a stamper, low water absorbability and transparency; and to an optical disk substrate and an optical disk obtained therefrom. More specifically, it relates to an optical disk substrate and an optical disk such as CD(Compact Disk), MO(Magneto-optical Disk) and DVD(Digital Versatile Disk), which have precision transferability and

hardly undergo warpage caused by environmental changes. In particular, the present invention relates to a substrate for a high density optical disk having a very large recording capacity.

[0002]

[Prior Art]

The recording densities of optical disks have been increasing from 0.6 GB of CD to 4.7 GB of DVD. However, along with progress in information technology, the development in the market of an optical disk field is remarkable, and the emergence of a high density optical disk capable of storing a larger amount of data is desired for the future. For example, an optical disk with a recording density of 100 Gbit/inch<sup>2</sup> or higher which can accommodate to an image of a high-definition TV such as digital broadcasting is desired.

[0003]

To increase the density of an optical disk, a distance between grooves or pits, i.e., a track pitch, is narrowed, thereby increasing a recording density in a track direction. For example, an increase in recording density from CD to DVD has been achieved by narrowing the track pitch from 1.6  $\mu\text{m}$  to 0.74  $\mu\text{m}$ .

[0004]

An optical disk substrate is produced by injection-molding (injection-compression-molding) a thermoplastic resin. At that time, fine pits and projections formed in advance on a stamper attached to a mold and correspond to recording/reproduction signals, are transferred onto the surface of the substrate from the stamper. Therefore, how to transfer the pits and projections of the stamper with high precision, i.e., precise transferability, at the time of molding the substrate is important. Particularly, in molding a high density optical disk substrate, such importance becomes conspicuous.

[0005]

For high density optical disks, it is important to comprise a substrate with precise transferability. In addition to this, it is also important to undergo smaller warpage of a substrate and smaller warpage with respect to environmental changes than conventional optical disks, due to the following reason. That is, along with an increase in density, the wavelength of laser is made shorter and the NA of pickup lens is made higher, so that even very small warpage of a substrate results in a large coma aberration, thereby causing a focus error or a tracking error. Further, since the pickup lens and the substrate become closer to each other due to the increase in NA, it is important that the warpage of the substrate and the warpage caused by environmental changes are small so as to prevent the lens and the substrate from making contact with each other.

[0006]

Heretofore, a polycarbonate resin has been used as a substrates for optical disks such as CD (Compact Disk), MO (Magneto-optical Disk) and DVD (Digital Versatile Disk) due to its excellent transparency, heat resistance, mechanical properties and dimensional stability.

[0007]

However, along with an increase in the recording densities of the optical disks, optical disk substrates made of the polycarbonate resin have been becoming unsatisfactory in view of precision transferability and warpage.

[0008]

To meet demand for an improvement in transferability, a variety of studies have heretofore been made in terms of both molding techniques and material modification. As for the former, for example, it has been confirmed that a method of setting a cylinder temperature and a mold temperature at the time of substrate molding at high temperatures is

effective. However, this method requires long cooling time in a mold because it is high temperature molding, thereby inviting problems in extending a molding cycle and resulting in low productivity. If molding is forcibly carried out in a high cycle, improper mold release occurs when a substrate is released from a mold, thereby resulting in deformed pits or grooves and lowering precision of transfer. As for the latter, for example, a method (JP-A 9-208684 and JP-A 11-1551, for example) comprising incorporating a large amount of a low molecular weight compound in a polycarbonate resin so as to impart high flowability or a method (JP-A 11-269260, for example) comprising using a specific long chain alkyl phenol as a terminal blocking agent is proposed. However, in the method of increasing the content of the low molecular weight compound or the method of modifying terminal groups by the long chain alkyl phenol, deterioration in thermal stability is generally remarkable. Therefore, as a result of promoting thermal decomposition at the time of molding, the mechanical strength of a disk substrate is significantly degraded, so that the substrate is cracked by force that pushes the substrate out of a mold or the substrate is broken during handling of the optical disk substrate.

[0009]

Thus, the prior arts were intended to improve transferability by improving the flowability of the resin. However, they failed to provide practicable substrates at high efficiency.

[0010]

Meanwhile, to meet demand for an improvement in warpage as well, a variety of studies have been made in terms of both molding techniques and material modification. As for the former, although warpage of a substrate could be kept small by finely controlling molding conditions, it was difficult to transfer the shape of a stamper precisely. As for the



latter, it is known to be effective to use a rigid material having a high flexural or tensile modulus. Accordingly, for the purpose of improving the rigidity of a polycarbonate resin, a method of adding such additives as glass fibers and a filler has been attempted. However, although the above additives improve the rigidity of the polycarbonate resin, a problem arose in that the fluidity at the time of injection molding tended to lower, thereby degrading precision of transfer. Further, there was another problem that the additives came up to the surface of the molded product frequently, so that they caused defective appearance of the substrate.

[0011]

As for warpage with respect to environmental changes, JP-A 2000-11449 proposes, in order to inhibit deformation caused by absorption of water, "a disk-shaped data recording medium which comprises a substrate, a recording layer disposed on the substrate so as to record data signals and a transparent protective layer laminated on the recording layer and on which data signals are recorded/reproduced by light entering from the transparent protective layer side, the substrate comprising a resin core layer and a resin surface layer which is integrated with the core layer, has pits and projections corresponding to data signals of the recording layer side on one surface and has higher flowability than the core layer, and the surface layer of the substrate being made of a resin having a water absorption of not higher than 0.3%", and suggests a complex substrate configuration by coinjection molding or sandwich molding so as to solve the problem.

[0012]

[Subject to Be Solved by the Invention]

An object of the present invention is to provide a polycarbonate resin composition having high rigidity, precision transferability to the shape of a stamper, low water

absorbability and transparency, and an optical disk substrate, an optical disk and particularly, a high density optical disk substrate which are obtained from the composition, have high precision transferability and hardly undergo warpage caused by environmental changes.

[0013]

Here, the "precise transferability" in the present invention refers to a characteristic that fine pits and projections formed on a stamper can be transferred precisely when an optical disk substrate is produced from a transparent, thermoplastic resin molding material by injection molding.

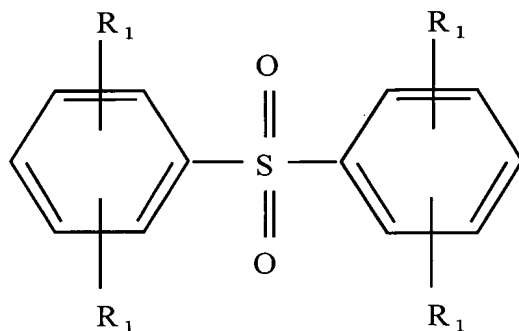
[0014]

[Means for Settling the Subject]

According to studies made by the present inventors, it has been found that the above object of the present invention is achieved by a polycarbonate resin composition comprising 0.1 to 20 parts by weight of a diphenyl sulfone compound (following formula [I]) and/or a phenylsulfonic acid phenyl ester compound (following formula [II]) based on 100 parts by weight of the polycarbonate resin; and by an optical disk substrate and an optical recording medium, which are formed from the above resin.

[0015]

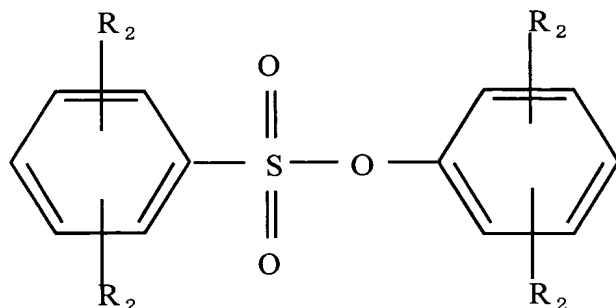
[Formula 3]



[ I ]

[0016]

[Formula 4]



[ II ]

[0017]

(wherein a plurality of  $R_1$ s and/or  $R_2$ s independently represents a hydrogen atom, a halogen atom, an alkyl group having 1 to 8 carbon atoms, an aryl group having 6 to 10 carbon atoms, an alkoxy group having 1 to 8 carbon atoms, a cyano group, a nitrile group, a carboxyamide group or a carboxyimide group.).

[0018]

When 0.1 to 20 parts by weight, preferably 0.5 to 10 parts by weight, of the diphenyl sulfone compound and/or the phenylsulfonic acid phenyl ester compound are added to the polycarbonate resin, the rigidity of the polycarbonate resin is drastically improved and further, its water absorbability is reduced, while retaining the excellent transparency. Further, the precision transferability at the molding time is improved and further, the warpage of the substrate by environmental change is reduced. When the above low-molecular weight additives are added in an amount larger than 20 parts by weight, the decline in the molecular weight of the polycarbonate resin composition becomes conspicuous, thereby resulting in worsening of the thermal stability, while the amount added of the additives is smaller than 0.1 part by weight, the effect of the above additives is not obtained.

[0019]

The diphenyl sulfone compound of the formula [I] is a compound having two benzene ring bonded to each other via a

sulfone group, which may have a substituent. Particularly, when a substituent having a high polarity is introduced to the above diphenyl sulfone compound, there can be obtained such effect that the resulting polycarbonate resin composition has increased rigidity and reduced water absorbability. The diphenyl sulfone compound of the formula [I] is a compound having two benzene ring bonded to each other via a sulfone group, which may have a substituent. The phenylsulfonic acid phenyl ester compound of the formula [II] is a compound in which phenols are esterified with a phenylsulfonic acid and which may have a substituent. When a substituent having a high polarity is introduced to these compounds, there can be obtained such effect that the resulting polycarbonate resin composition has increased rigidity and reduced water absorbability. Examples of the substituent having a high polarity include a halogen atom, an alkyl group having 1 to 8 carbon atoms, an aryl group having 6 to 10 carbon atoms, an alkoxy group having 1 to 8 carbon atoms, a cyano group, a nitrile group, a carboxyamide group or a carboxyimide group. Of these, a hydrogen atom, a halogen atom, an alkyl group having 1 to 4 carbon atoms, an aryl group having 6 to 8 carbon atoms or an alkoxy group having 1 to 4 carbon atoms is particularly preferred. Specific preferred compounds are diphenyl sulfone, difluorophenyl sulfone and phenylsulfonic acid phenyl ester.

[0020]

Hereinafter, the present invention will be described in details. The polycarbonate resin used in the present invention is generally obtained by reacting a dihydric phenol with a carbonate precursor according to an interfacial polymerization method or a melt polymerization method. Typical examples of the dihydric phenol include hydroquinone, resorcinol, 4,4'-dihydroxydiphenyl, bis(4-hydroxyphenyl)methane,

bis((4-hydroxy-3,5-dimethyl)phenyl)methane,  
 1,1-bis(4-hydroxyphenyl)ethane,  
 1,1-bis(4-hydroxyphenyl)-1-phenylethane,  
 2,2-bis(4-hydroxyphenyl)propane (bisphenol A),  
 2,2-bis((4-hydroxy-3-methyl)phenyl)propane,  
 2,2-bis((4-hydroxy-3,5-dimethyl)phenyl)propane,  
 2,2-bis((3,5-dibromo-4-hydroxy)phenyl)propane,  
 2,2-bis((3-isopropyl-4-hydroxy)phenyl)propane,  
 2,2-bis((4-hydroxy-3-phenyl)phenyl)propane,  
 2,2-bis(4-hydroxyphenyl)butane,  
 2,2-bis(4-hydroxyphenyl)-3-methylbutane,  
 2,2-bis(4-hydroxyphenyl)-3,3-dimethylbutane,  
 2,4-bis(4-hydroxyphenyl)-2-methylbutane,  
 2,2-bis(4-hydroxyphenyl)pentane,  
 1,1-bis(4-hydroxyphenyl)cyclohexane,  
 1,1-bis(4-hydroxyphenyl)-4-isopropyl cyclohexane,  
 1,1-bis(4-hydroxyphenyl)-3,3,5-trimethyl cyclohexane,  
 9,9-bis(4-hydroxyphenyl)fluorene,  
 9,9-bis((4-hydroxy-3-methyl)phenyl)fluorene,  
 1,1'-bis(4-hydroxyphenyl)-ortho-diisopropyl benzene,  
 1,1'-bis(4-hydroxyphenyl)-meta-diisopropyl benzene,  
 1,1'-bis(4-hydroxyphenyl)-para-diisopropyl benzene,  
 1,3-bis(4-hydroxyphenyl)-5,7-dimethyl adamantane,  
 4,4'-dihydroxydiphenyl sulfone, 4,4'-dihydroxydiphenyl  
 sulfoxide, 4,4'-dihydroxydiphenyl sulfide,  
 4,4'-dihydroxydiphenyl ketone, 4,4'-dihydroxydiphenyl ether,  
 4,4'-dihydroxydiphenyl ester,  
 1,1-bis(4-hydroxyphenyl)-2-methylpropane,  
 1,1-bis(4-hydroxyphenyl)-2-ethylhexane, and  
 2,2-bis(4-hydroxyphenyl)-4-methylpentane. These may be  
 used alone or in combination of two or more.  
 [0021]

Of these, 2,2-bis(4-hydroxyphenyl)propane (bisphenol  
 A), 1,1-bis(4-hydroxyphenyl)-2-methylpropane and

2,2-bis(4-hydroxyphenyl)-4-methylpentane are preferred.

[0022]

Illustrative examples of the carbonate precursor used in producing the polycarbonate by use of the dihydric phenol include a carbonyl halide, a carbonate ester and a haloformate. Specific examples thereof include phosgene, diphenyl carbonate and dihaloformate of dihydric phenol. Of these, phosgene and diphenyl carbonate are preferred.

[0023]

When the above dihydric phenol and carbonate precursor are reacted with each other by a method such as a solution polymerization or a melt polymerization to produce the polycarbonate resin, a catalyst, a terminal blocking agent and an antioxidant for the dihydric phenol may be used as required.

[0024]

A reaction by the interfacial polymerization method is generally a reaction between a dihydric phenol and phosgene and is carried out in the presence of an acid binder and an organic solvent. As the acid binder, an alkali metal oxide such as sodium hydroxide or potassium hydroxide or an amine compound such as pyridine is used, for example. As the organic solvent, a halogenated hydrocarbon such as methylene chloride or chlorobenzene is used, for example. Further, a catalyst such as a tertiary amine, a quaternary ammonium compound or a quaternary phosphonium compound, e.g., triethylamine, tetra-n-butyl ammonium bromide and tetra-n-butyl phosphonium bromide, can be used so as to accelerate the reaction. In that case, it is preferable that the reaction temperature be generally 0 to 40°C, that the reaction time be about 10 minutes to 5 hours and that the pH during the reaction be kept at 9 or higher.

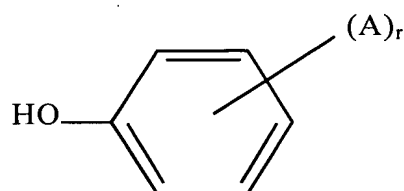
[0025]

Further, in the polymerization reaction, a terminal

blocking agent is generally used. As the terminal blocking agent, a monofunctional phenol can be used. The monofunctional phenol is generally used as a terminal blocking agent so as to control a molecular weight, and since a polycarbonate resin obtained by use of the monofunctional phenol has its terminals blocked by groups based on the monofunctional phenol, it has better thermal stability than a polycarbonate resin obtained without using the monofunctional phenol. An example of the monofunctional phenol is a monofunctional phenol that is generally phenol or a lower alkyl substituted phenol and is represented by the following formula [III]:

[0026]

[Formula 5]



[III]

[0027]

(wherein A is a hydrogen atom or a linear or branched alkyl or phenyl substituted alkyl group having 1 to 9 carbon atoms, and r is an integer of 1 to 5, preferably 1 to 3.)

[0028]

Specific examples of the above monofunctional phenol include phenol, phenyl phenol, p-t-butyl phenol, p-cumyl phenol and isooctyl phenol.

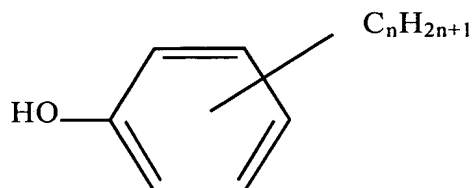
[0029]

Further, as other monofunctional phenols, phenols or benzoic acid chlorides having a long chain alkyl group or aliphatic ester group as a substituent or long chain alkyl carboxylic acid chlorides can be used. When they are used to block the terminals of a polycarbonate polymer, they not

only act as a terminal blocking agent or a molecular weight modifier but also improve the melt flowability of the resin so as to facilitate moldability. In addition, they have an effect of lowering physical properties as a substrate, particularly the water absorption of the resin, and an effect of reducing the birefringence of the substrate. Hence, they are preferably used. In particular, phenols which have a long chain alkyl group as a substituent and are represented by the following formulae [IV] and [V] are preferably used.

[0030]

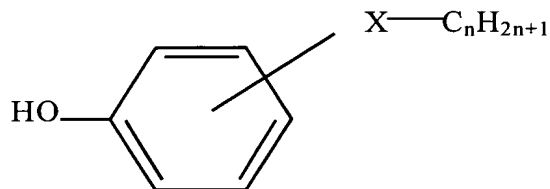
[Formula 6]



[IV]

[0031]

[Formula 7]



[V]

[0032]

(In the above formulae, X is -R-O-, -R-CO-O- or -R-O-CO-, wherein R is a single bond or a divalent aliphatic hydrocarbon group having 1 to 10, preferably 1 to 5 carbon atoms, and n is an integer of 10 to 50.)

[0033]

As the substituted phenol of the above formula (IV), a substituted phenol in which n is 10 to 30 is preferred, and a substituted phenol in which n is 10 to 26 is particularly preferred. Specific examples thereof include decyl phenol, dodecyl phenol, tetradecyl phenol, hexadecyl phenol,



octadecyl phenol, eicosyl phenol, docosyl phenol and triacontyl phenol.

[0034]

Further, as the substituted phenol of the above formula (V), a compound in which X is -R-CO-O- and R is a single bond is appropriate, and a compound in which n is 10 to 30, particularly 10 to 26, is suitable. Specific examples thereof include decyl hydroxybenzoate, dodecyl hydroxybenzoate, tetradecyl hydroxybenzoate, hexadecyl hydroxybenzoate, eicosyl hydroxybenzoate, docosyl hydroxybenzoate and triacontyl hydroxybenzoate.

[0035]

These terminal blocking agents are desirably introduced into at least 5 mol%, preferably at least 10 mol%, of all terminals of the obtained polycarbonate resin. Further, the terminal blocking agents may be used alone or in admixture of two or more.

[0036]

A typical reaction by the melt polymerization method is generally an ester exchange reaction between a dihydric phenol and a carbonate ester, and is carried out by a method in which the dihydric phenol and the carbonate ester are mixed together under heating in the presence of an inert gas while an alcohol or phenol produced is distilled out. Although the reaction temperature varies depending on the boiling point of the alcohol or phenol produced, it generally ranges from 120 to 350°C. In the late stage of the reaction, the reaction system is reduced to about 10 to 0.1 Torr (1,300 to 13 Pa) so as to facilitate distill-out of the alcohol or phenol produced. The reaction time is generally about 1 to 4 hours.

[0037]

As the carbonate ester, an ester of an aryl group having 6 to 10 carbon atoms, an alkyl group or alkyl group having 1 to 4 carbon atoms, which may have a substituent, may be used.

Specific examples thereof include diphenyl carbonate, ditolyl carbonate, bis(chlorophenyl)carbonate, m-cresyl carbonate, dinaphthyl carbonate, bis(diphenyl)carbonate, dimethyl carbonate, diethyl carbonate and dibutyl carbonate. Of these, diphenyl carbonate is preferred.

[0038]

Further, to increase the polymerization rate, a polymerization catalyst can be used. As the polymerization catalyst, catalysts which are generally used in an esterification reaction and an ester exchange reaction, such as alkali metal compounds, e.g., sodium hydroxide, potassium hydroxide and sodium and potassium salts of dihydric phenol; alkaline earth metal compounds, e.g., calcium hydroxide, barium hydroxide and magnesium hydroxide; nitrogen-containing basic compounds, e.g., tetramethylammonium hydroxide, tetraethylammonium hydroxide, trimethylamine and triethylamine; alkoxides of alkali metals and alkaline earth metals; organic acid salts of alkali metals and alkaline earth metals. In addition thereto, zinc compounds, boron compounds, aluminum compounds, silicon compounds, germanium compounds, organotin compounds, lead compounds, osmium compounds, antimony compounds, manganese compounds, titanium compounds and zirconium compounds can be used. These catalysts may be used alone or in combination of two or more. These polymerization catalysts preferably are used in an amount of  $1 \times 10^{-8}$  to  $1 \times 10^{-3}$  equivalents, more preferably  $1 \times 10^{-7}$  to  $5 \times 10^{-4}$  equivalents, per mole of the dihydric phenol as a raw material.

[0039]

Further, in the polymerization reaction, to reduce phenolic terminal groups, a compound such as bis(chlorophenyl)carbonate, bis(bromophenyl)carbonate, bis(nitrophenyl)carbonate, bis(phenylphenyl)carbonate, chlorophenylphenyl carbonate, bromophenylphenyl carbonate,

nitrophenylphenyl carbonate, phenylphenyl carbonate, methoxycarbonylphenylphenyl carbonate or ethoxycarbonylphenylphenyl carbonate is preferably added in the late stage or after completion of the polycondensation reaction. Of these, 2-chlorophenylphenyl carbonate, 2-methoxycarbonylphenylphenyl carbonate and 2-ethoxycarbonylphenylphenyl carbonate are preferably used, and 2-methoxycarbonylphenylphenyl carbonate is particularly preferably used.

[0040]

The viscosity average molecular weight of the polycarbonate resin is preferably within a range of 10,000 to 30,000, more preferably 12,000 to 20,000. A polycarbonate resin optical molding material having the above viscosity average molecular weight is preferred since it has satisfactory strength as an optical material and has good melt flowability at the time of molding so that no molding distortion occurs, advantageously. When the molecular weight is excessively low, the strength of a resulting molded substrate is not satisfactory, while when it is excessively high, melt flowability at the time of molding is poor and consequently, an undesirable optical distortion increases in the substrate.

[0041]

After the polycarbonate resin as a raw material is produced by a conventionally known method (such as a solution polymerization method or a melt polymerization method), it is preferably filtered in a solution state so as to remove impurities such as unreacted components and foreign matters.

[0042]

The resin composition of the present invention is prepared by use of any method. For example, a method which comprises mixing the diphenyl sulfone compound and/or the phenylsulfonic acid phenyl ester compound into the

polycarbonate resin in a solution state, distilling out a solvent and then melt-pelletizing the resulting mixture by a vented extruder or the like or a method comprising mixing the polycarbonate resin with the diphenyl sulfone compound and/or the phenylsulfonic acid phenyl ester compound by use of a super mixer, a tumbler, a Nauta mixer or the like and pelletizing the mixture by use of a twin screw extruder or the like. Further, if necessary, additives such as a stabilizer, an antioxidant, a light stabilizer, a colorant, a lubricant and a mold release agent can be added. Further, in the extrusion step (pelletizing step) of obtaining a pellet-shaped polycarbonate resin to be injection-molded, the composition is preferably passed through a sintered metal filter having a filtration accuracy of 10  $\mu\text{m}$  during melt stage so as to remove foreign matters therefrom. In any event, it is necessary to minimize the contents of foreign matters, impurities and solvents in the raw material resin before injection molding.

[0043]

To produce an optical disk substrate from the above polycarbonate resin, an injection molding machine (including an injection compression molding machine) is employed. As the injection molding machine, a generally used machine may be used. However, an injection molding machine whose cylinder and screws show low adhesion to the resin and which is made of a material exhibiting corrosion resistance and abrasion resistance is preferably used so as to inhibit the occurrence of carbides and to increase the reliability of the disk substrate. As for conditions for injection molding, a cylinder temperature of 300 to 400°C and a mold temperature of 50 to 140°C are preferred. By these conditions, an optically excellent optical disk substrate can be obtained. The atmosphere in the molding step is preferably as clean as possible in consideration of the objects of the present

invention. Further, it is important to fully dry the material to be molded so as to remove water therefrom and also important to be careful not to allow residence that may cause decomposition of the molten resin.

[0044]

The thus molded optical disk substrate is suitably used as a substrate not only for current optical disks such as a compact disk (CD), a magneto-optical disk (MO) and DVD but also for high density optical disks that are typified by a Blu-ray Disc (BD) on which recording and reproduction are conducted via a 0.1-mm-thick transparent cover layer placed on the disk substrate.

[0045]

Since the polycarbonate resin optical molding material of the present invention has high precise transferability, an optical disk substrate having a distance between grooves or pits of 0.1 to 0.8  $\mu\text{m}$ , preferably 0.1 to 0.5  $\mu\text{m}$ , more preferably 0.1 to 0.35  $\mu\text{m}$ , can be obtained easily by molding. Further, an optical disk substrate whose groove or pit has an optical depth of  $\lambda/8n$  to  $\lambda/2n$ , preferably  $\lambda/6n$  to  $\lambda/2n$ , more preferably  $\lambda/4n$  to  $\lambda/2n$  in which  $\lambda$  is the wavelength of laser beam used for recording and reproduction and  $n$  is the refractive index of the substrate, can be obtained. Thus, a substrate for a high density optical disk recording medium having a recording density of 100 Gbit/inch<sup>2</sup> or higher can be provided easily.

[0046]

[Examples]

Hereinafter, the present invention will be further described in detail with reference to Examples. The present invention shall not be limited by these Examples in any way as long as the spirit of the present invention is upheld. "Parts" in Examples and Comparative Examples refers to parts by weight. Evaluations were made in accordance with the

following methods.

[0047]

(1) viscosity average molecular weight

A specific viscosity ( $\eta_{sp}$ ) obtained by using a 20°C solution prepared by dissolving 0.7 g of polycarbonate resin in 100 mL of methylene chloride was substituted into the following expression to determine a viscosity average molecular weight.

$$\eta_{sp}/c = [\eta] + 0.45 \times [\eta]^2 c \quad ([\eta] \text{ is a limiting viscosity.})$$

$$[\eta] = 1.23 \times 10^{-4} M^{0.83}$$

$$c = 0.7$$

[0048]

(2) glass transition temperature

A glass transition temperature was measured in a nitrogen atmosphere (nitrogen flow rate: 40 ml/min) at a temperature increasing rate of 20°C/min by use of the thermal analysis system DSC-2910 of TA Instruments Co., Ltd.

[0049]

(3) water absorption

In accordance with ASTM D-570, a  $\phi 45$ -mm molded plate was immersed in water, and water absorption was determined from a rate of change in weight (% by weight).

[0050]

(4) flexural modulus

A flexural modulus was measured in accordance with ASTM D-790.

[0051]

(5) transferability

An optical disk substrate having a diameter of 120 mm and a thickness of 1.2 mm was molded by use of the injection molding machine MO40D-3H of Nissei Plastic Industrial Co., Ltd. and a stamper on which grooves each having a depth of 200 nm and a width of 0.2  $\mu$ m were engraved at an interval of 0.5  $\mu$ m. The cylinder temperature and the mold clamping force

were fixed at 360°C and 40 tons, respectively, and the mold temperature was set for each resin as shown in Table 1.

The depths of grooves transferred from the stamper onto the above substrate were measured on 5 spots on a radius of 40 mm by use of an atomic force microscope (SPI3700 of Seiko Instruments Inc.). Transferability was expressed as a transfer rate represented by the following expression. The larger the value, the better the transferability is.

$$\text{transfer rate (\%)} = 100 \times (\text{depth of groove of disk}) / (\text{depth of groove of stamper})$$

[0052]

(6) initial mechanical property (initial R-Tilt)

An optical disk substrate having a diameter of 120 mm and a thickness of 1.2 mm was molded by use of the injection molding machine MO40D-3H of Nissei Plastic Industrial Co., Ltd. Then, on the signal surface side of the disk substrate obtained by injection molding, a reflection film, a dielectric layer 1, a phase change recording film and a dielectric layer 2 were deposited by sputtering, and a thin polycarbonate film cover layer was laminated thereon to prepare an optical disk. Then, a spacer was inserted between the disks so as to prevent the disks from contacting each other, and the disks were left to stand at a temperature of 23°C and a humidity of 50%RH for at least two days. Tilt is evaluated by use of the three-dimensional shape measuring instrument DLD-3000U of Japan EM Co., Ltd. when a change in the Tilt with respect to thermal contraction and environmental changes was settled, and the Tilt was taken as an initial mechanical property.

[0053]

(7) maximum value of curvature deformation ( $\Delta R$ -Tiltmax)

After a substrate whose initial mechanical property has been evaluated is left to stand in constant-temperature constant-humidity equipment whose temperature is 30°C and

humidity is 90%RH for 72 hours, the disk is transferred to an environment whose temperature is 23°C and humidity is 50%RH, and the maximum value ( $\Delta R$ -Tiltmax) of curvature deformation of the disk is then evaluated by the three-dimensional shape measuring instrument DLD-3000U of Japan EM Co., Ltd.

Examples 1 to 3 and Comparative Examples 1 to 2

To 100 parts by weight of polycarbonate resin (product of Teijin Chemicals Ltd.) obtained by using bisphenol A as a dihydric phenol component and having a viscosity average molecular weight of 15,200, additive compounds were added in parts by weight shown in Table 1, and mixed uniformly. Then, the powders were melt-kneaded by a vented twin-screw extruder [KTX-46 of Kobe Steel, Ltd.] at a cylinder temperature of 260°C under deaeration to obtain pellets of the resin compositions. Using the above resin composition pellets, various physical properties were evaluated by the above-mentioned methods. The results of the evaluations are shown in Table 1.

[0054]

From these resin composition pellets, optical disk substrates each having a diameter of 120 mm and a thickness of 1.2 mm were molded by using the injection molding machine MO40D-3H of Nissei Plastic Industrial Co., Ltd. and a stamper on which grooves each having a depth of 200 nm and a width of 0.2  $\mu$ m were engraved at an interval of 0.5  $\mu$ m. The cylinder temperature and the mold clamping force were fixed at 360°C and 40 tons, respectively, and the mold temperature was set for each resin as shown in Table 1. By use of these disk substrates, various substrate properties were evaluated by the above-mentioned methods. The results of the evaluations are shown in Table 1. Diphenyl sulfone compound and/or the phenylsulfonic acid phenyl ester compound listed in Table 1 are as follows.

diphenyl sulfone: diphenyl sulfone of Tokyo Kasei Kogyo Co., Ltd.



difluorodiphenyl sulfone: 4,4-difluorodiphenyl sulfone of  
Tokyo Kasei Kogyo Co., Ltd.

phenylsulfonic acid phenyl ester: phenylsulfonic acid  
phenyl ester of Tokyo Kasei Kogyo Co., Ltd.

[0055]

[Table 1]

	Ex. 1	Ex. 2	Ex. 3	C.Ex. 1	C.Ex. 2
type of additive	diphenyl sulfone	difluoro-diphenyl sulfone	phenylsulfonic acid phenyl ester	-	glass fibers
added amount (wt%)	5	5	5	0	10
glass transition temperature T <sub>g</sub> (°C)	127	124	118	142	142
water absorption (%)	0.20	0.19	0.22	0.28	0.28
flexural modulus (MPa)	3,000	3,100	2,850	2,500	3,700
total light transmittance [%]	91	91	90	91	84
mold temperature T <sub>m0</sub> (°C)	110	107	101	125	125
ΔT(°C)*	17	17	17	17	17
initial R-Tilt (deg)	0.08	0.06	0.07	0.09	0.28
ΔR-Tilt (deg)	0.59	0.54	0.63	0.92	0.95
transfer rate (%)	100	100	100	54	12

Ex. : Example C.Ex. : Comparative Example

\* ΔT = difference between glass transition temperature and mold temperature =

T<sub>g</sub> - T<sub>m0</sub>

[0056]

[Effect of the Invention]

According to the present invention, there can be provided an optical recording medium molded from a specific polycarbonate resin, particularly an optical disk substrate which allows the shape of a stamper to be transferred thereon and hardly undergoes warpage caused by environmental changes with high precision as a high density recording medium and hence, the effects obtained are extremely high.

[Title of Document]      Abstract

[Abstract]

[Subject]

To provide a polycarbonate resin composition and an optical disk substrate obtained from the same, which have high stiffness, precise transferability to the shape of a stamper, low water absorption and transparency.

[Means of Solution]

A polycarbonate resin composition comprising 0.1 to 20 parts by weight of a diphenyl sulfone compound and/or phenyl sulfonic acid phenyl ester compound based on 100 parts by weight of the polycarbonate resin, an optical disk obtained therefrom and an optical recording medium obtained therefrom.

[Selected drawing]      nil